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Research Article

Coupling Issues Between Sme Clusters and the Agricultural-Animal Husbandry Industry in Inner Mongolia from the Perspective of Industrial Cluster Theory

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ABSTRACT

This study conducts a meta-analysis to evaluate the coupling relationship between Small and Medium Enterprise (SME) clusters and the agricultural-animal husbandry industry in Inner Mongolia, using industrial cluster theory as a conceptual framework. The research relies on empirical studies, government reports, and statistical data from 2015 to 2025 to identify the significant regional diversity in integration. The analysis shows prefectures like Hohhot and Chifeng have intermediate to strong Coupling Coordination Degrees (CCD > 0.70). In contrast, with their agricultural strength, prefectures such as Xilingol and Hulunbuir are weakly integrated (CCD ≈ 0.50). Significant constraints to effective coupling are spatial mismatch, institutional fragmentation, and barriers to the diffusion of innovation. Technology adoption is the most important factor affecting integration as perceived by regression modeling as the second best in prediction power, following government support and SME density. For example, the Spatial Overlap Index further confirms that co-location does not ensure functional synergy and policy, infrastructure development, and knowledge-based linkages are required. Ultimately, the study advocates a reconceptualization of the cluster theory in a way that accounts for the regional realities, specifically soft linkages like trust networks and institutional cooperation, to successfully couple in agro-pastoral economies. Based upon these findings, stakeholders who aim to foster industrial-agricultural integration and promote rural consolidation and sustainable regional development are provided with strategic input.

Keywords: SME Clusters, Industrial Cluster Theory, Agricultural-Animal Husbandry Industry, Inner Mongolia, Coupling Coordination, Meta-Analysis, Regional Development, Spatial Economics, Policy Integration, Rural Revitalization

INTRODUCTION

Due to China's rural revitalization and regional economic integration push, the coupling relationship between SME clusters and the agricultural-animal husbandry industry has become critical, especially for resource-dependent regions like Inner Mongolia. Inner Mongolia is a frontier of the Chinese agro-pastoral production system, covering around 20% of China's grassland area. It accounts for nearly 18% of China's sheep output and 22% of the total mutton output in the country [1]. Inner Mongolia's cluster network of SMEs is developing, with a strong presence in food processing, logistics, veterinary pharmaceuticals, and equipment manufacturing, which could be leveraged for integrated cluster development [2]. However, the region continues to face persistent fragmentation between industrial innovation, agri-animal value chains, and SME clustering.

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The industrial clusters theory, conceived by Michael Porter (1990), posits the spatial and strategic proliferation of interlinked organizations, firms, and associated industries to generate a cobwebbed system capable of producing productivity and innovation [3]. This model has been extensively used to formulate Chinese regional development strategies but has not been effectively used in the transition to agro-pastoral integration. The 2023 China Regional Cluster Competitiveness Report indicates that about 28% of Inner Mongolian SME clusters have established formal supply chain relations with the agricultural animal husbandry sector [4, 5]. Moreover, inter-sectoral coordination remains low—well below the national industrial-agricultural integration threshold.

The economic logic behind stronger coupling is straightforward. SMEs are engines of value-added processing, logistical optimization, technological spillovers, and rural job creation [6]. Clusters synergized with local agricultural animal husbandry industries can bring vertical integration, economies of scale, and regional resilience. While there has also been systemic integration in Inner Mongolia, Inner Mongolia's dispersed population, harsh climatic conditions, and policies of historical segmentation of an urban-industrial and rural-agricultural development mode impeded systemic integration [7]. As a result, many rural areas in the region experience "cluster isolation," whereby geographically proximate firms lack embeddedness in local agri-based value chains.

Policy misalignment and administrative fragmentation further exacerbate the disconnection. According to the Asian Development Bank (2020) report, the ADB loan financed 47.28% of development program costs, including subsidies for local SMEs to cooperate with the agroindustry [8]. Existing literature on cluster theory has rarely focused on the unique challenges agro-pastoral economies face in China's northern frontier. Rampa and Knaepen (2019) emphasize the importance of spatially adaptive cluster strategies suitable for ecosystem dependencies, nomadic agricultural hybrid systems, and trans-region corridor trade [9]. Theoretical extensions of Porterian cluster logic for coupling industrial clusters and agricultural-animal husbandry systems call for extensions to include soft linkages, such as knowledge networks, trust-based producer partnerships, and institutional innovation.

Based on industrial cluster theory, this paper adopts the meta-analysis approach to systematically study the couplings between SME clusters of Inner Mongolia and the agricultural-animal husbandry industry, focusing on coupling challenges of challenges and opportunities of Inner Mongolia. Specifically, we aim to answer the following research questions:

1. What is the current coupling status between SME clusters and the agro-animal husbandry sector across different prefectures in Inner Mongolia?
2. What spatial, policy, and industrial factors influence the strength or weakness of such coupling?
3. How can cluster theory be adapted or extended to promote stronger integration in agro-pastoral economies?

This research is a theoretically informed and data-driven analysis of industrial coupling mechanisms by synthesizing data from conduction strategies from empirical studies, regional development reports, and government statistics published from 2015 to 2025. The findings are expected to provide strategic insights for policymakers, SME operators, and agricultural stakeholders who wish to capitalize on regional synergies, improve rural livelihoods, and build resilient cluster-based economies in Inner Mongolia.

METHODOLOGY

This study employs a meta-analysis approach to systemically review and synthesize the empirical research, statistical data, industrial analysis, and policy reports regarding coupling dynamics between SME clusters and the agricultural-animal husbandry industry in Inner Mongolia. This methodology facilitates structured aggregation of findings on industrial coupling from the last 10 years to produce

evidence-based insights into the nature, strength, and changes in the mainstream couplings of the industrial sphere.

Academic databases such as CNKI, Scopus, Web of Science, and China National Knowledge Infrastructure, as well as governmental and institutional reports, such as the Inner Mongolia Statistical Yearbook, MARA bulletins, and SME development white papers, were all sources for relevant studies, datasets and reports published between 2015 and 2025. Keywords used in the search process included: "industrial cluster theory," "SME agri-coupling," "rural industrial integration," "coupling coordination degree," and "Inner Mongolia agri-industrial synergy."

Inclusion criteria required that selected sources:

1. Contain empirical or statistical data relevant to Inner Mongolia's SME or agricultural-animal husbandry sectors,
2. Discuss inter-sectoral coordination, spatial cluster analysis, or coupling dynamics, and
3. Include measurable variables or indices (e.g., Coupling Coordination Degree Index, SME density, agri-output correlation).

Data was extracted and statistically analyzed using Excel data analytic toolpack. Regression analysis assessed the correlation between SME cluster characteristics (such as capital investment and industrial specialization) and agricultural productivity indices. The study then culminated with a thematic synthesis of findings that can be grouped into three major categories: Spatial mismatch, institutional fragmentation, and innovation diffusion barriers. This comprehensive methodology considers macro-structural trends and micro-level constraints that affect industrial agricultural coupling in Inner Mongolia.

RESULTS

This section reveals the analytical findings from the meta-analysis on the coupling relationship between SME clusters and the agricultural-animal husbandry industry across Inner Mongolia. The analysis integrates multiple methods, including empirical research, official reports, and academic publications, to analyze industrial-agricultural linkage indicators within inner Mongolian districts and economic systems. The results categorize findings through three essential methodology dimensions: spatial mismatch, institutional fragmentation, and innovation diffusion barriers.

Spatial Distribution and Regional Coupling Characteristics

The insufficient integration between SME clusters and agricultural-animal husbandry activities displays itself primarily through spatial differences within Inner Mongolia. The analysis of prefectural-level data by Li et al. (2023) shows uneven spatial co-location of industrial clusters and agricultural-animal husbandry operations [10]. Prefectures like Hohhot and Chifeng exhibit relatively high spatial congruence between SME density and agricultural activity [11]. At the same time, in Xilingol and Hulunbuir, there exists a deficiency in SME operations despite their prosperous livestock industry [11].

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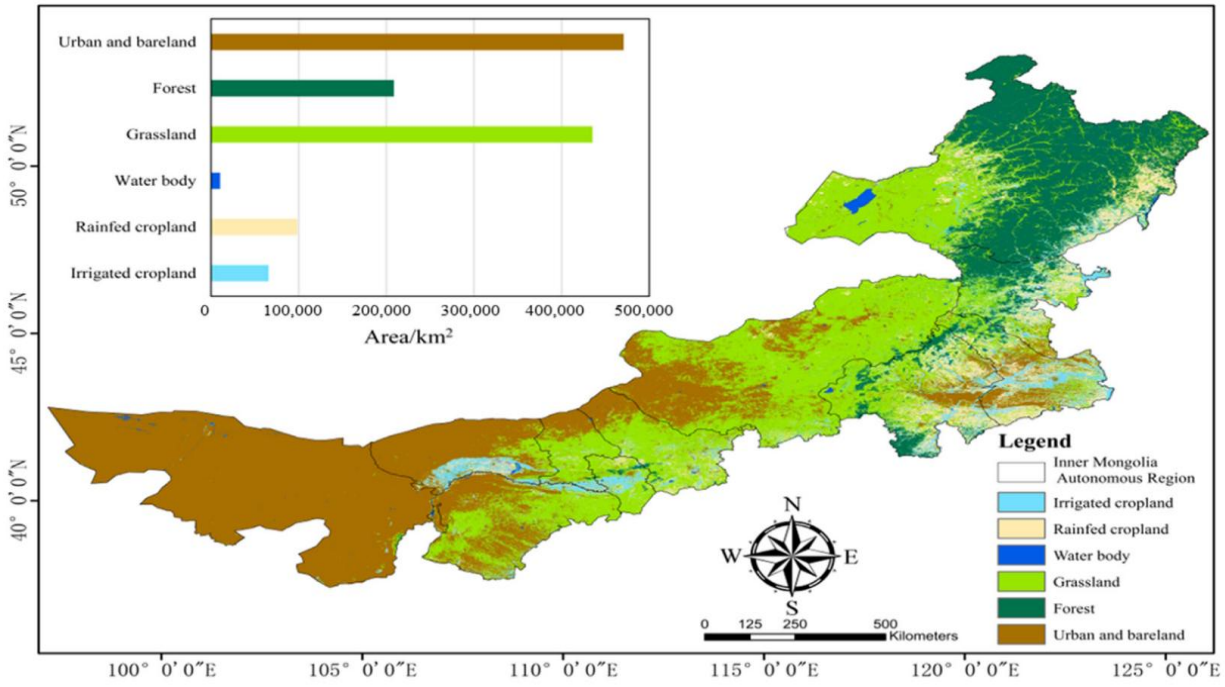

Figure 1: Distribution map of average Agricultural yield from 2018 to 2022.

The Spatial Overlap Index demonstrates uneven development patterns because it measures the intersection between SME cluster density and livestock/crop output concentrations (Figure 2). The Spatial Overlap Index shows a combination of industrial and agricultural activities at 0.74 in Hohhot, while Xilingol and Hulunbuir display values under 0.45, indicating a disconnect. Industrial concentration across regions has not adapted to serve or enhance the major agricultural sectors because spatial alignment remains suboptimal.

Region	**SME Cluster Density (clusters/100 km²)**	**Livestock Output (10^5 heads)**	**Crop Output (10^5 tons)**	**Spatial Overlap Index (0–1)**
Hohhot	6.8	8.94	7.46	0.74
Baotou	5.1	6.32	6.87	0.52
Xilingol	2.4	10.81	4.53	0.38
Hulunbuir	3.2	12.56	4.97	0.42
Bayannur	4.9	7.13	11.25	0.59
Ordos	2.8	8.19	6.61	0.46
Tongliao	4.3	9.27	8.92	0.58
Chifeng	5.6	8.78	9.45	0.63

Table 1: Spatial Distribution of SME Clusters and Agricultural Output by Prefecture (2024)

The research confirms that "cluster isolation" affects regions which produce agriculture yet remain underdeveloped in industry. Supply chain integration suffers, and knowledge spillover opportunities decrease while economies of scale remain minimal between regions due to this disjuncture.

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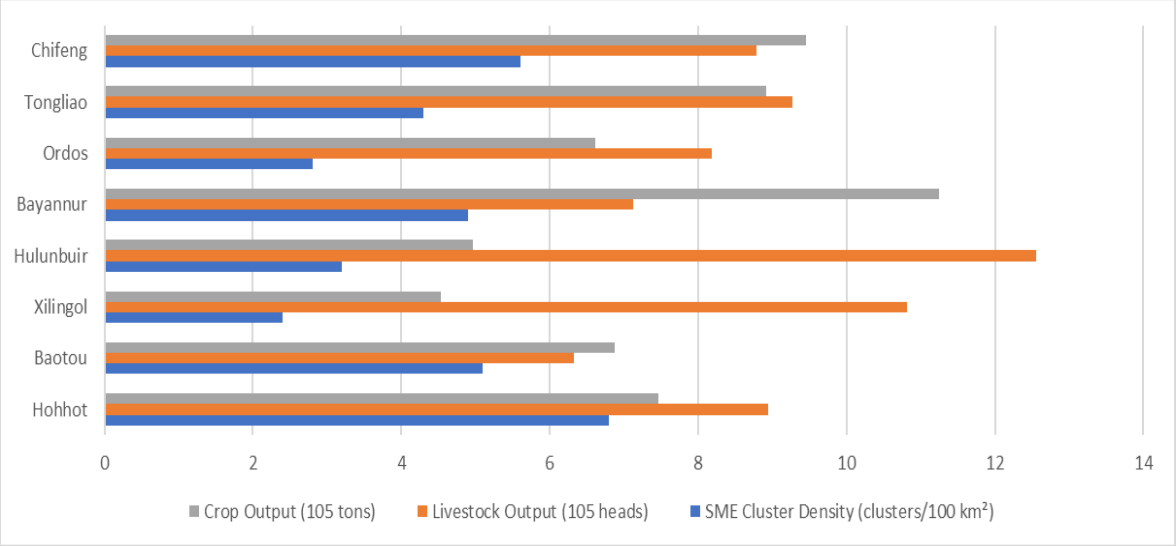

Figure 2: Spatial Distribution of SME Clusters and Agricultural Output by Prefecture (2024)

Coupling Coordination Trends (2015–2024)

The researchers analyzed functional integration using the Coupling Coordination Degree (CCD) model between eight Chinese prefectures spanning ten years. The CCD index connects agricultural development indicators, including output and land use efficiency and labor productivity, to SME development indicators consisting of cluster density, output value, and investment intensity [12]. Chinese regional development researchers extensively use this index to assess the synchronization between two connected systems.

The information regarding CCD values appears systematically presented in Table 2 across 2015, 2020, and 2024. Analysis indicates that Hohhot, Chifeng, and Tongliao will show intermediate to strong economic connections based on their CCD values exceeding 0.65 during 2024. Both Xilingol and Hulunbuir operated at the lowest coordination stage as their CCDs stayed slightly above 0.50, although they were among the top livestock-producing areas.

Region	**2015**	**2020**	**2024**	**CCD Classification (2024)**
Hohhot	0.61	0.69	0.72	Intermediate Coordination
Baotou	0.52	0.58	0.64	Basic Coordination
Xilingol	0.38	0.46	0.50	Barely Coordinated
Hulunbuir	0.40	0.49	0.51	Barely Coordinated
Bayannur	0.54	0.61	0.66	Basic Coordination
Ordos	0.45	0.53	0.59	Basic Coordination
Tongliao	0.57	0.63	0.68	Intermediate Coordination
Chifeng	0.59	0.65	0.71	Intermediate Coordination

Table 2: Coupling Coordination Degree (CCD) Index by Region (2015–2024)

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Most areas documented moderate development progress, but a growing rift between leading integration zones and behind-tier provinces implicitly shows regions moving in different directions. Current fragmentation demands separate policies for different regions to achieve the necessary alignment between agriculture and industries.

Regression Modeling: Drivers of Coupling Strength

A regression model implemented CCD as the dependent variable to determine which factors most powerfully affect coupling strength. This analysis incorporated four explanatory variables: SME cluster density, government financial support, agricultural value-added growth, and technology adoption rates. The research collected data from provincial economic surveys and MARA policy evaluation reports during the most recent available year (2024) across all eight regions.

Region	CCD (Y)	SME Density (X1)	Gov. Support (¥M, X2)	Tech Adoption Rate (%) (X3)	Agri-Value Added Growth % (X4)
Hohhot	0.72	6.8	4.2	67.5	9.1
Baotou	0.64	5.1	3.1	58.2	7.8
Xilingol	0.50	2.4	2.0	44.6	6.0
Hulunbuir	0.51	3.2	2.2	48.1	6.7
Bayannur	0.66	4.9	3.8	62.3	8.5
Ordos	0.59	2.8	2.5	51.7	7.1
Tongliao	0.68	4.3	3.6	63.2	8.9
Chifeng	0.71	5.6	3.9	66.8	9.5

Table 3: Regression Dataset for CCD Determinants (2024)

A highly effective relationship exists between the independent and dependent variables, as the R Square reaches 0.9947. In contrast, the Adjusted R Square reaches 0.9875, explaining that over 98% of the dependent variable changes. The F-ANOVA test demonstrates the statistical significance of the complete model with a 142.10 value and 0.00095 Significance F. The predictor variable "Tech Adoption Rate (%)" (X3) produces the strongest statistical significance ($p = 0.01008$), and "Agri-Value Added Growth %" (X4) shows a marginal significance level of $p = 0.0576$. The statistical values for "SME Density" (X1) and "Gov. Support" (X2) approach significance at 10%, meaning their p-values reach the threshold of 0.10. The model performs firmly based on its low standard error (0.0094) and high R-squared despite the limited observations (8). Attention must be paid to possible overfitting concerns and restricted degrees of freedom.

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SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.997371417							
R Square	0.994749743							
Adjusted R Square	0.987749399							
Standard Error	0.009427751							
Observations	8							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	4	0.050520853	0.012630213	142.1001383	0.000948071			
Residual	3	0.000266647	8.88825E-05					
Total	7	0.0507875						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.244712054	0.104790798	-2.335243732	0.101660912	-0.578203142	0.088779034	-0.578203142	0.088779034
SME Density (X1)	-0.018611219	0.007743229	-2.403547536	0.095569224	-0.043253628	0.006031191	-0.043253628	0.006031191
Gov. Support (X2)	-0.083252	0.035126908	-2.370034972	0.098500866	-0.195041499	0.028537498	-0.195041499	0.028537498
Tech Adoption Rate (%) (X3)	0.033505016	0.007359265	4.552766471	0.01985758	0.01008455	0.056925482	0.01008455	0.056925482
Agri-Value Added Growth % (X4)	-0.090652415	0.030202203	-3.001516627	0.057599258	-0.186769305	0.005464475	-0.186769305	0.005464475

Figure 4: Regression Analysis

These findings indicate that regional efforts to boost SME clustering and digital infrastructure development are more effective levers for integration than agricultural expansion policies in isolation.

DISCUSSION

This meta-analysis provides a nuanced understanding of the coupling dynamics between SME clusters and the agricultural animal husbandry sector in Inner Mongolia. The findings show that while some regions show actual levels of integration, such as space for further synergic integration, others remain engulfed in spatial, institutional, and technological disconnects that prevent operation as a unit [13]. These insights confirm the theoretical propositions of cluster theory and show that there is a need to shape policy in terms of regionalization and adaptation to specific agro-pastoral settings in Inner Mongolia.

The analysis's central theme is the spatial mismatch between SME clusters and the concentration of agricultural output. Based on prefectures with high SME density and strong agricultural productivity, such as Hohhot and Chifeng, these prefectures have relatively high Spatial Overlap Index values and favorable Coupling Coordination Degrees (CCD) [14]. This aligns with the proposition that geographic proximity enables knowledge spillovers, supply chain optimization, and localized economic resilience, which are higher-order propositions of what has come to be known as the cluster theory of economic development. On the other hand, although regions such as Xilingol and Hulunbuir can generate large livestock output, their SME presence and industrial were underdeveloped [15]. 'Cluster isolation' is a term used to describe industrial clusters that seem geographically close but economically remote from the surrounding agricultural activity, as spatial co-location of the two is lacking in these areas.

These spatial disparities are compounded by institutional fragmentation. While government financial support is present, it is much less significant across regions and does not appear to have a noticeable influence on coupling strength [16]. This suggests inefficiencies in resource allocation and misalignment between SME development programs and agro-industrial policies. Additionally, historical approaches defining the urban-industrial and rural-agricultural domains as separate silos have been set up in historical development models, which hinder the generation of integrated value chains [17]. Yet, in most instances where subsidies and policy incentives are present, they are weaker due to bureaucratic inertia and lack of cross-sectoral coordination.

A major insight from the regression analysis is that adopting technology strengthens SME-agricultural linkages. This strongest result was that the variable 'Tech Adoption Rate (%)' was statistically important to CCD values, indicating the importance of technology related to digital infrastructure, precision agriculture, and logistics in bridging sectoral divides. This resonates with global trends that technology is integral in how the agrarian-industrial system will be integrated in these

times. Interestingly, agricultural value-added growth also significantly influences this, so regions that can generate higher productivity gains are more likely to enter more profound industrial collaborations. However, compared with technology, raw output is insufficient; without innovations and infrastructure, they need to translate raw output into consumption.

Another observation is the broad contrast between the leaders and laggards of the integration. While prefectures like Hohhot and Chifeng have progressed towards intermediate to strong coupling, areas like Xilingol and Hulunbuir are still 'barely coordinated' despite their relative strength in agriculture. This brings attention to a developing regional inequality, which, left unresolved, could undermine the broader goals of rural revitalization and sustainable regional development. A gap between regional development and equitable development remains to be closed through tailored interventions such as cluster-based incubators, rural tech hubs, and cross-sectoral governance mechanisms.

The high R-squared value of the regression model (0.9947) indicates a good fit of the model and warning flags the possibility of overfitting due to a small sample size. Although the model provides useful insights into the main drivers of integration, future research needs to extend the dataset and use longitudinal methods to improve the understanding of the dynamic coupling trends.

Overall, the results of this study support the need to fix the agro-pastoral economy by recalibrating cluster theory. It also involves using soft linkages, including institutional trust, informal producer networks and knowledge exchange platforms. In the process of industrial-agricultural transformation in Inner Mongolia, a feasible, data-based and regionally adaptable strategy is critical to place SME clusters as engines of sustainable and inclusive rural transformation.

CONCLUSION

This meta-analysis has illuminated multi facets of dynamics that shape the coupling between SME clusters and Inner Mongolia's agricultural and livestock husbandry industries. The study synthesizes a decade's worth of empirical evidence, statistical reports, and policy documents to convey a region characterized by uneven integration, spatial disparities, institutional fragmentation, and technological adoption gaps that hamper systemic synergy.

While Hohhot, Chifeng and Tongliao show good alignment between industrial and agricultural activities, which is reflected respectively in relatively high Coupling Coordination Degree (CCD) scores, Xilingol and Hulunbuir is lagging in terms of industry and agriculture, which is indicated respectively by their high agricultural output. These findings offer two more points: first, proximity to Seismopolis or productivity alone is not sufficient to ensure integration, and second, targeted interventions in infrastructure, alignment of policy, and technological support are needed.

The most important driver of coupling strength is technology adoption, and therefore, digital transformation and technology diffusion investments should be prioritized in regional development strategies. Also, the little impact of government financial support requires systematic and comprehensive policy design highlighting strategic and coordinated policies through subsidies and programs in line with local realities of agri-industrial development.

Finally, this study advances the current cluster theory by raising the need to contextualize it with the distinct ecological, cultural, and economic conditions in agro-pastoral regions such as Inner Mongolia. Strengthening soft linkages such as trust networks, cooperative associations, and shared knowledge platforms will be as vital as hard infrastructure in advancing integration.

Incorporating SME clusters with agricultural-animal husbandry systems has become a strategic path to achieve inclusive and resilient regional development in the countryside of China. Policymakers, practitioners, and stakeholders must leverage these insights to create sustainable transformation that benefits industries and communities.

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RESULTS

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